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TRANSFER OF TRAINING IN MOTOR LEARNING AS A FUNCTION OF DISTRIBUTION OF PRACTICE

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FOREWORD

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ABSTRACT

Transfer between a first and a second task, both available on the same piece of equipment, was studied as a function of the distribution of practice on both the first and the second task. There were two experiments. In the first there were three degrees of distribution of practice trials over days on both the first and the second tasks; all trials on any one day were separated by 10-second rests. In the second experiment practice within a day was continuous (0 second intertrial rest). All trials on the first task were given on one day and two degrees of distribution of practice over days were used for the second task. All groups in both experiments were given the same total amount of practice.

In the first experiment distribution of trials over days did not produce differential performance on either the first or second tasks. Positive transfer to the second task was the same for all groups; transfer was not found to vary as a function of distribution of practice trials over days.

In the second experiment acquisition of the second task did not vary as a function of the distribution of continuous-practice trials over days.

When the two experiments were compared it was found that performance late in practice was poorer in groups given continuous trials in comparison with groups given 10-second inter-trial rests. This was found on both the first and second tasks. There was no difference between the two experiments in transfer to the second task; equal positive transfer was found regardless of whether prac tice was with or without inter-trial rests.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDING GENERAL:

Robert H. Blount

ROBERT H. BLOUNT
Colonel, USAF (MC)
Chief, Aero Medical Laboratory
Directorate of Research

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TRANSFER OF TRAINING IN MOTOR LEARNING AS A FUNCTION OF DISTRIBUTION OF PRACTICE

I. INTRODUCTION

The purpose of the study was to investigate transfer from a first to a second task in motor learning as a function of distribution of practice on both tasks. The motor skill used in the study has been described in a previous report (2) and is explained below in detail. Briefly, the subject is required to make specific movements of a lever, grasped by the right hand, in response to visual stimuli while simultaneously holding, by the left hand, another lever in a fixed position. Both tasks are provided on the same apparatus; the second task is made available by newly pairing the stimuli and responses (lever movements) of the first task.

In the previous study (2), where the same tasks were used, it was shown that transfer between these tasks was always positive. Transfer increased directly both with degree of learning of the first task and with degree of formal similarity between tasks. In the present study the effect on transfer of another variable, distribution of practice, is studied. Although there has been much research on distribution of practice as a variable in learning (5,6), there is no information available as to the effect of this variable on transfer. Since practice on training devices may in some cases be crowded into a short period of time, while in other cases it may be distributed over a longer period, it would seem worthwhile to investigate whether such variation has any effect on transfer.

II. PROCEDURE

Apparatus: Since the apparatus has been described in detail in a previous report (2), it need be explained here only briefly. The stimuli were six different hues presented in random order on the same ground-glass screen. The subject moved a lever, grasped by the right

hand, into any one of six slots cut in a steel plate and arranged as radii of an 8 inch circle. The subject had to learn which light was associated with each slot. Simultaneously the subject held another lever with the left hand. This was essentially a steadiness test since the subject merely had to hold the lever in a fixed position. If this left-hand lever was out of position, the subject was informed by a 1000 cycle tone, delivered through earphones. The two levers were wired together in such a way that even if the subject had the right-hand lever in the slot that was correct for the stimulus light showing, a correct response was not recorded if the left-hand lever was out of position. A panel of telephone jacks and sockets enabled the experimenter to connect any light with any slot and thereby provide a new task for the subject within a few seconds.

Complete entries into correct slots (correct responses), complete entries into incorrect slots (deep errors), and partial entries into incorrect slots (shallow errors) were recorded on separate Veeder-Root counters. Deep errors were recorded whenever the subject oscillated the right-hand lever at the end of a correct slot at any time while holding the left-hand lever incorrectly. The time that the left-hand was held correctly in position was recorded on a .01 sec. Standard Electric clock. The apparatus was subject-paced, i.e., the subject could work as fast as he liked. Ordinarily the apparatus was set to provide, automatically, 20-second work periods (trials) and 10-second inter-trial rests, but the apparatus could also be set to run continuously. The complete wiring diagram and photographs of the apparatus may be found in the previous report.

Experimental Design: As stated in the introduction, the purpose of the experiment was to study transfer as a function of distribution of practice. There were three degrees of distribution of practice trials over days on both the first and the second tasks. All subjects were given 36 trials on each task. Each trial consisted of 20 seconds of work and the trials were separated by 10-second rests. The 36 trials on each task were distributed over 1, 2 or 3 days in different groups. The factorial design of the experiment is shown in Table 1. As the table shows, groups were differentiated on the basis of whether the 36 trials on a task were given all on one day, 18 trials a day on two successive days, or 12 trials on each of three days. The entries in the body of Table 1 show that there were 15 subjects in each cell, 135 subjects in all.

The Tasks: For the first task the lights were paired with the slots in 15 different combinations. Each subject in a cell of 15 subjects was assigned one of these combinations. The same 15 combinations were used for each of the nine cells of subjects. For each of the 15 combinations another combination for use on the second task was made up by newly pairing each light with a different slot. Again,

each subject in a cell was assigned one of these second-task combinations and the same 15 combinations were used for all cells on the second task. The 15 combinations for both the first and second tasks were chosen from those used in the experiment described in the first report (2). Because of the method of choosing the combinations, as described in the previous report, the first and second tasks can be considered equal in difficulty. Thus no control groups were run; data from the first task serve as control for the second task.

Subjects and Method: The subjects were 135 males enrolled in the introductory psychology course at Northwestern University. They were rewarded with one point of examination credit for each day served in the experiment. In addition, they were told that the experiment was being done for the Air Force. From the subjects comments it appeared that motivation was high.

When the subjects first appeared for the experiment they were given a crude color discrimination test which consisted of calling out the names of the six stimulus lights as they were presented in random order. Following the color naming, the subject was asked to take his place in front of the apparatus with his hands on the levers. Then the height of the table carrying the apparatus was adjusted until the tops of the levers were approximately one in. below elbow height. Since the subjects stood up for all practice trials, this height seemed to be the least fatiguing.

Table 1 - The Design of the Experiment

		Final task distribution		
		A 36	B 18-18	C 12-12-12
Original Task Distribution	I 36	15	15	15
	II 18-18	15	15	15
	III 12-12-12	15	15	15

The purpose of the experiment was explained to the subjects in very simple terms, using every day situations, e.g., driving two different makes of automobiles. A rather lengthy set of instructions had been previously worked out. The gist of the instructions was as follows: The subject was told that he was to learn, by moving the right-hand lever into the slots, which light was connected to which slot, but it was emphasized that this was not sufficient; he was to turn off as many lights as possible during the 20-sec. trial. He was informed that during the 10-sec. rest periods he would be told how many correct responses he had made, i.e., how many lights he had turned off during the previous trial.

On the day a subject was to begin the second task he was told that now the lights and slots were connected in a different way and that he was to go ahead and learn this task in the same way he had the first one.

III. RESULTS

Although four response measures were recorded for each subject on both the original and final task, the results of only two of these, correct responses and shallow errors, will be presented. It was shown elsewhere (2) that these two measures better reflected the performance of the subjects than did the deep errors or the time scores. As the circuits of the apparatus were designed, deep errors were recorded when the subject depressed the correct response switch in the correct slot with the tone on. This makes the deep entry error record a function of both incorrect responses with the right-hand lever and incorrect performance on the steadiness test. Performance on the steadiness test, as reflected in the time scores, was shown in the preceding study (2) to vary with the amount of time spent in manipulating the apparatus, rather than as some function of the variables used in the study.

A word should be said about the notation that is to be used to identify the various groups. The three degrees of distribution of trials over days for the original task will be designated by I, II, and III, denoting the groups that had, respectively, all 36 trials in one day, 18 trials a day on two successive days, and 12 trials a day on three successive days. The three degrees of day distribution for the final task will be designated A, B, and C, with the number of trials per day distributed as in the original task. The group designations for both the original and final task will be preceded by the letter D, indicating that these groups practiced under a 20 second-10 second work-rest cycle.

The Original Task: The performance data for the three groups were analyzed by blocks of trials, with the blocks corresponding to the degrees of day-distribution. For any one block of 12, 18, or 36 trials, each subject was assigned a score that was the total number of correct responses or shallow errors made during that block of trials. Table 2 presents a summary of the correct-responses data, showing the means and standard errors of the six blocks of trials for the three groups, with the t-ratios for the means compared. The corresponding information for the shallow errors is shown in Table 3.

The groups were matched on the basis of the total number of correct responses made in the first 12 trials of practice. The adequacy of matching is shown in the first entry of Table 2 for correct responses and the first entry of Table 3 for shallow errors. The t-ratios between pairs of means of these groups were all less than one.

As can be seen from these tables, there are no significant differences among the three groups in any of the blocks of trials. For Groups D-II and D-III there were slight decreases in correct responses and slight increases in shallow errors immediately following the 24-hour intervals; these differences, however, were not significant.

The three groups, D-I, D-II and D-III, were combined for both correct responses and shallow errors to form the control groups for the final task.

The Final Task: A summary of the data for correct responses and shallow errors is shown in Tables 4 and 5. The experiment was originally planned as a factorial design to permit use of analysis of variance. However, there was heterogeneity of variance, as determined by Bartlett's test, among the nine groups for all 36 second-task trials. In addition, there appeared to be nothing systematic in the heterogeneity of variance; it was not associated with rows, columns, or diagonals. In the first attempt to circumvent this difficulty, the square root transformation was applied, since in addition to heterogeneity there seemed to be some tendency for means and variances to be correlated. Secondly, the logarithmic transformation (of the raw data) was tried. The transformations, and the tests for homogeneity, were done separately for the blocks of trials 1-12, 13-24, 25-36, and 1-36 both for correct responses and shallow errors. Using Bartlett's test on both transformations, all chi-squares but one were significant at the 5% level, several of them at the 1% level. Thus, both transformations failed to remove the heterogeneity of variance. The data will therefore be analyzed by the non-parametric analysis of variance method described by Moses (6).

Table 2 - Mean Number of Correct Responses in 12-, 18- and 36-Trial Blocks of the Original Task for the Three Degrees of Day-Distribution for Experiment I, Together with the t-Ratios for the Groups Compared. N = 45 in each Group

	Group D-I		Group D-II		Group D-III	
Trials	Mean	σ_m	Mean	σ_m	Mean	σ_m
1-12	41.77	2.09	42.30	2.14	43.24	1.92
13-24	76.40	4.48	69.04	3.54	72.30	4.38
25-36	103.20	4.55	102.67	4.30	101.78	4.98
1-18	74.75	4.16	74.77	3.79	74.31	3.77
19-36	146.62	6.61	139.24	5.85	141.91	7.19
1-36	221.37	10.43	214.02	9.31	216.33	10.42

t-Ratios for Groups Compared

Trials	D-I vs D-II	D-I vs D-III	D-II vs D-III
1-12	.17	.16	.02
13-24	1.29	.65	.58
25-36	.07	.20	.13
1-18	.00	.08	.00
19-36	.83	.48	.29
1-36	.52	.34	.16

Table 3 - Mean Number of Shallow Errors in Successive 12-, 18- and 36-Trial Blocks of the Original Task for the Three Degrees of Day-Distribution for Experiment I, Together with the t-Ratios for the Groups Compared. N = 45 in each Group

	Group D-I		Group D-II		Group D-III	
Trials	Mean	σ_m	Mean	σ_m	Mean	σ_m
1-12	130.00	4.98	126.48	5.22	127.84	4.89
13-24	83.30	7.59	89.66	6.88	99.44	7.87
25-36	41.02	5.47	46.40	6.44	58.88	7.97
1-18	176.20	8.16	171.15	8.51	185.11	8.05
19-36	76.13	8.79	91.40	9.64	100.04	11.92
1-36	252.29	15.46	262.55	16.48	285.18	18.09

t-Ratios for Groups Compared

Trials	D-I vs D-II	D-I vs D-III	D-II vs D-III
1-12	.48	.31	.19
13-24	.62	1.47	.93
25-36	.64	1.87	.88
1-18	.43	.77	1.19
19-36	1.17	1.61	.56
1-36	.45	1.38	.92

Table 4 - Mean Correct Responses and Standard Errors of the Means on the Second Task for Various Blocks of Trials for the Three Degrees of Distribution of Practice on the First Task (D-I, D-II and D-III) and the Three Degrees of Distribution on the Second Task (A, B, and C) in Experiment I

		Blocks of Trials					
Group		1-12	13-24	25-36	1-18	19-36	1-36
D-I A	M	75.73	121.73	146.20	131.26	212.40	343.66
	σ_M	5.79	7.22	8.00	9.14	11.65	18.51
D-I B	M	69.80	91.73	116.06	116.06	161.53	277.60
	σ_M	5.24	6.85	7.74	8.96	10.95	18.41
D-I C	M	79.73	111.66	133.13	130.80	193.93	324.73
	σ_M	6.98	7.93	5.18	10.48	8.50	18.50
D-II A	M	77.26	111.07	129.83	127.46	186.93	314.40
	σ_M	7.51	8.67	6.77	12.13	10.42	21.78
D-II B	M	79.40	112.40	135.00	133.66	193.13	328.00
	σ_M	4.54	5.79	5.26	7.56	7.88	13.58
D-II C	M	71.60	103.93	130.70	119.80	186.46	306.26
	σ_M	4.70	6.23	8.19	7.79	10.29	16.85
D-III A	M	84.26	124.93	133.46	140.73	195.26	336.00
	σ_M	6.00	7.77	6.65	9.80	9.68	18.26
D-III B	M	78.40	109.46	131.26	130.73	188.40	319.13
	σ_M	6.58	10.38	11.00	11.14	16.73	26.05
D-III C	M	80.40	105.20	113.66	128.00	171.26	299.26
	σ_M	6.72	8.54	10.31	10.87	13.95	24.43

Table 5 - Mean Shallow Errors and Standard Errors of the Means on the Second Task for Various Blocks of Trials for the Three Degrees of Distribution of Practice on the First Task (D-I, D-II, and D-III) and the Three Degrees of Distribution on the Second Task (A, B and C) in Experiment I

		Blocks of Trials					
Group		1-12	13-24	25-36	1-18	19-36	1-36
D-I A	M	115.80	48.27	20.87	148.07	36.87	184.93
	σ_m	14.36	9.21	4.51	19.04	7.83	24.74
D-I B	M	104.80	62.27	33.60	132.53	68.80	201.33
	σ_m	11.55	12.13	8.57	16.83	15.09	30.93
D-I C	M	105.40	52.73	31.93	142.13	47.93	190.07
	σ_m	12.92	9.23	4.74	17.49	8.17	24.89
D-II A	M	99.53	39.47	19.47	124.73	33.73	158.47
	σ_m	12.64	9.17	5.03	17.49	8.17	24.14
D-II B	M	104.47	57.13	25.87	136.13	51.33	187.47
	σ_m	12.30	14.47	8.54	20.47	14.43	33.99
D-II C	M	123.47	68.33	30.73	167.53	55.00	222.53
	σ_m	11.69	9.90	6.70	16.26	9.56	23.73
D-III A	M	113.60	45.53	25.20	140.33	44.00	184.33
	σ_m	13.28	10.93	8.47	17.96	13.91	29.83
D-III B	M	120.07	62.20	40.67	150.47	72.47	222.93
	σ_m	12.47	11.49	10.14	17.00	16.38	30.04
D-III C	M	106.00	61.93	54.27	143.53	78.67	222.20
	σ_m	9.39	12.14	14.26	14.29	18.97	31.56

Each chi-square resulting from applying the non-parametric method is obtained by arranging the means, for any one block of trials, in a 3 x 3 table in which the rows correspond to degrees of distribution of practice on the first task (Groups D-I, D-II, and D-III) and the columns are degrees of distribution on the second task (A, B, and C). Thus, a 3 x 3 table is formed from the nine means in each column in Tables 4 and 5. For such a table one chi-square is computed for rows and another for columns. Thus the chi-square for Groups D-I, D-II, and D-III is a test for significance of difference in performance on the second task of groups having different degrees of distribution of practice on the first task. The chi-squares for Groups A, B, and C also tests for significance of difference on the second task but of groups differing in practice distribution on the second task. Tables 6 and 7 show the chi-squares for correct responses and for errors respectively.

As Table 6 shows, there are no significant differences on the second task for any block of trials for either group differing in degree of distribution of practice on the first or on the second task. No differences in second-task performance were obtained as a function of practice distribution. When errors is the measure, one significant difference is obtained, among Groups D-I, D-II, and D-III on trials 25-36, as shown in Table 7. It is not believed that any particular importance should be attached to this one significant value. We shall conclude that the results of Experiment I are negative; no difference in mastery of the first or the second task or in transfer was obtained by varying distribution of practice on either task.

Positive transfer was obtained in changing from the first to the final task. All groups began the second task at essentially the same level, which was above the control. The amount of transfer was not computed since the interest was in differential transfer. Because no differential transfer was found, the procedure was reviewed and the possibility occurred that the 10-second rest interval between trials might have been counteracting the day-distribution by allowing time for the dissipation of possible inhibitory factors built up during the 20-second work period. Therefore, two additional groups of subjects were run in which there were no inter-trial rests, i.e., practice was continuous.

IV. EXPERIMENT II

The problem in the second experiment was to provide, essentially, a control group for the data of Experiment I, in which the subjects performed under continuous practice on each day but with trials

Table 6 - Chi-squares Obtained by Non-parametric Analysis of Variance Applied to the Correct Responses Data of the Second Task for Various Blocks of Trials both for Groups Differing on the First Task and Groups Differing on the Second Task in Degree of Distribution of Practice in Experiment I

Trials	First-Task Distribution	Second-Task Distribution
1-12	2.66	.66
13-24	.66	2.66
25-36	.66	.66
1-18	2.66	2.66
19-36	.66	2.66
1-36	.66	2.66

Chi-square for 2 df = 5.99 at P = .05, 9.21 at P = .01

Table 7 - Chi-squares Obtained by Non-parametric Analysis of Variance Applied to the Shallow Error Data of the Second Task for Various Blocks of Trials both for Groups Differing on the First Task and Groups Differing on the Second Task in Degree of Distribution of Practice in Experiment I

Trials	First-Task Distribution	Second-Task Distribution
1-12	.66	0
13-24	.66	4.66
25-36	6.00*	4.66
1-18	.66	.66
19-36	4.66	4.66
1-36	.66	4.66

*Significant at $P < .05$

distributed over days. Two groups of subjects, 15 in each group, were given 12 minutes of continuous practice on the first of two tasks, all on one day. In the second task, one group was given 12 minutes of continuous practice on one day and the other group was given four minutes of continuous practice per day on three successive days. The practice, in terms of time, was the same for the various groups in both Experiment I and II.

Procedure

The apparatus used in this experiment was identical with the one used in Experiment I, except that the continuous-practice circuit was used.

The subjects were 30 male college students from the beginning psychology classes and were naive with respect to the apparatus. All subjects were given the color discrimination test as in Experiment I.

The procedure was the same as in Experiment I, except that the subjects were told they were to work continuously until the signal to stop. The number of correct responses made by the subject was again reported every 20 seconds. A timer independent of the apparatus was used to indicate the 20-second intervals.

The performance of the subjects was recorded in terms of correct responses and shallow errors.

Results

In learning the first task of this experiment the 30 subjects served under the same condition, i.e., 12 minutes of continuous practice on one day. The subjects were divided into two groups before original learning for the differential conditions of the second task. However, the performance on the first task was analyzed and the results showed correct responses and shallow errors for the two groups to be essentially the same; the data were therefore combined to form the control for the final task. For purposes of notation these combined data will be referred to as the C-M group, indicating that the practice was continuous with all practice on one day.

The notation for the two groups of this experiment on the final task will be as follows: the letters A and C will denote, respectively, the day-distribution of the group having 12 minutes of practice on one day, and the group having four minutes of practice per day on three successive days. Each of these letters will be preceded by the letter C, indicating that the practice was continuous within a day.

The data for the second task were analyzed by successive blocks of 12 trials and for the total trials, for the two groups. A summary of the means, SE's and the t-ratios for the correct responses and the shallow errors is presented in Table 8. As can be seen in the table, none of the differences is significant.

The data of Group C-C show decrements in performance following a 24-hour rest, as was observed in the data of Experiment I. The t-ratio for the difference between the means of the pairs of trials immediately before and immediately after the first 24-hour rest (trials 11 and 12 versus trials 13 and 14) is significant at the five percent level, for both correct responses and shallow errors. The difference in performance levels before and after the second 24-hour rest (trials 23 and 24 versus trials 25 and 26) is not significant for either of the response measures.

V. EXPERIMENT I AND EXPERIMENT II COMPARED

The data presented above show no inter-experiment differences which may be attributed to either type of distribution of practice. However, since the two experiments provided four groups having differential distribution of practice, but otherwise comparable, these data were brought together and analyzed.

In comparing the groups from the two experiments, unequal N's and heterogeneity of variance were encountered. When either or both of these conditions existed, the t-ratios were computed as suggested by Edwards (3).

The Original Task: In Experiment II, both groups of subjects were given 12 minutes of continuous practice. The group from Experiment I that is comparable to this condition was Group D-I, which had thirty-six 20-second trials all on one day. These two groups were compared for the original task and the summary of this analysis is shown in Table 9, for both correct responses and shallow errors. One mean difference was found significant, and this at the 1 percent level. This difference was for correct responses over the block of trials 25-36, with Group D-I attaining the higher performance level. A difference such as this would ordianrily be predicted on the basis of differential degree of distribution of practice, as has been reported in numerous studies.

The performance levels produced by the differential practice conditions of the two experiments are shown in Figure 1, for correct responses, and in Figure 2, for shallow errors. These curves, which

Table 8 - Mean Number of Correct Responses and Shallow Errors in 12- and 36-Trial Blocks of the Final Task in Experiment II, Together with the t-Ratios for the Groups Compared. N = 15 in Each Group

Correct Responses

	Group C-A		Group C-C		
Trials	Mean	σ_m	Mean	σ_m	t-Ratios
1-12	73.52	4.61	74.60	6.44	.13
13-24	100.20	9.41	91.13	7.86	.71
25-36	105.33	7.13	113.13	8.41	.68
1-36	279.06	20.65	278.86	20.79	.00

Shallow Errors

	Group C-A		Group C-C		
Trials	Mean	σ_m	Mean	σ_m	t-Ratios
1-12	129.93	11.96	127.60	11.16	.13
13-24	84.40	12.94	94.27	15.07	.48
25-36	55.87	7.93	56.60	13.04	.01
1-36	270.20	29.53	278.47	35.55	.17

Table 9 - Mean Number of Correct Responses and Shallow Errors of Continuous-Practice Group C-M (N = 30) From Experiment II and Distributed-Practice Group D-I (N = 45) From Experiment I for Various Blocks of Trials on the Original Task, Together with the t-Ratios For Groups Compared

Correct Responses

	Group C-M		Group D-I		
Trials	Mean	σ_m	Mean	σ_m	t-Ratios[a]
1-12	44.33	1.83	41.77	2.09	.92
13-24	66.17	3.89	76.44	4.48	1.74
25-36	84.20	4.19	103.15	4.55	3.09**[a]
1-36	195.30	8.92	221.37	10.42	1.91

Shallow Errors

	Group C-M		Group D-I		
Trials	Mean	σ_m	Mean	σ_m	t-Ratios[a]
1-12	135.17	7.12	130.02	4.98	.59
13-24	88.86	8.99	83.33	7.59	.47
25-36	55.97	6.74	41.02	5.47	1.73
1-36	280.00	20.08	252.29	15.46	1.10

**Significant at P = .01

[a]The t-ratios were computed by an approximation method (3, p. 167-168).

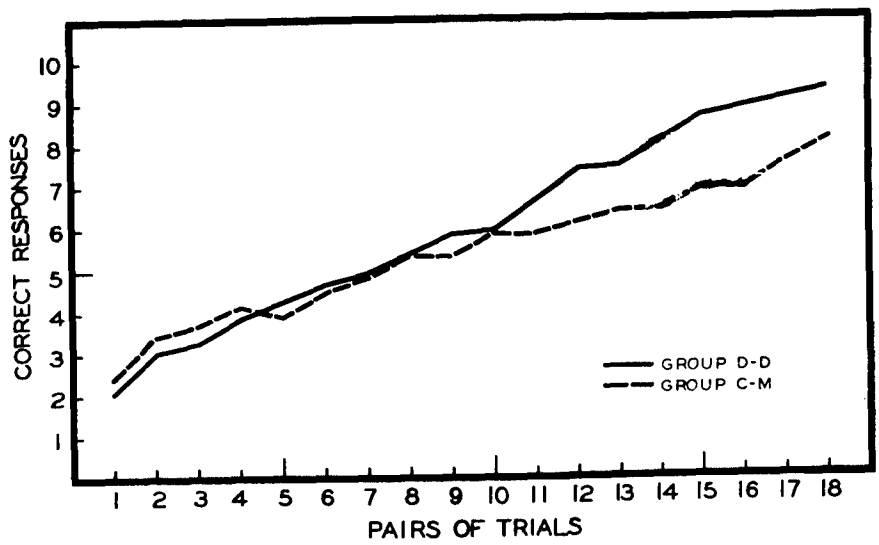

Fig. 1. Mean performance curves of correct responses on original learning for all subjects of Experiment I (Group D-D) and Experiment II (Group C-M).

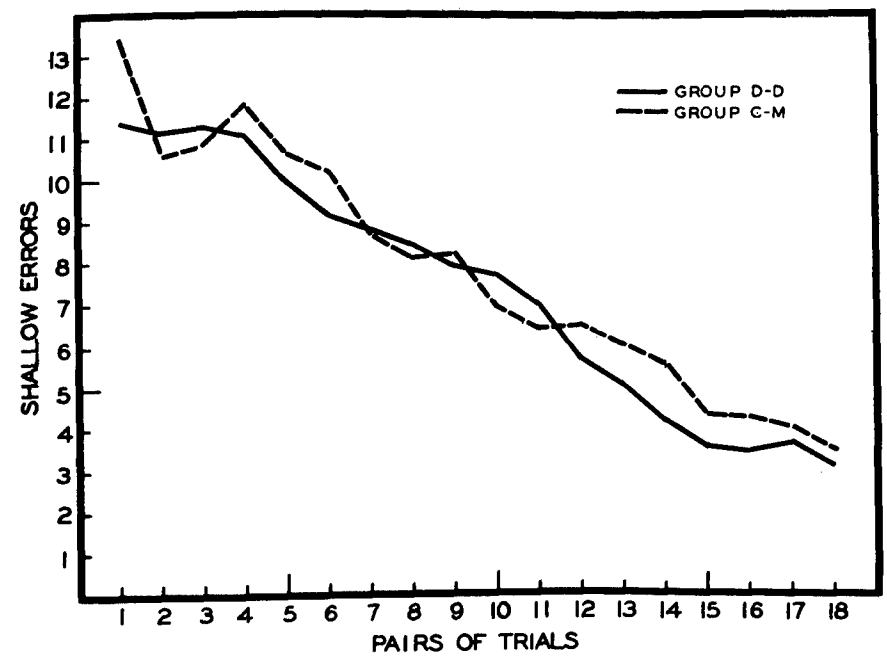

Fig. 2. Mean performance curves of shallow errors on original learning for all subjects of Experiment I (Group D-D) and Experiment II (Group C-M).

were constructed from the mean performance of all the subjects during the original task in each of the two experiments, served as controls for second-task learning. The groups from Experiment I that were combined (Groups D-I, D-II, and D-III) form one groups that will be called Group D-D. The difference between the performance levels of the two practice conditions of the two experiments, in terms of correct responses, is shown clearly in Figure 1. From these curves it can be seen that at abscissa point 10 (mean of trials 20 and 21) the two curves began to diverge, with Group D-D attaining a significantly higher performance level. The shallow error curves do not differ significantly, as can be seen from Table 8.

The Final Task: It may be well to review the notation of the four groups compared in this section: Group C-A, continuous practice, 12 minutes of practice given all in one day; Group C-C, continuous practice, practice distributed as four minutes per day on three successive days; Group D-A, 20 second-10 second work-rest cycle, 36 trials given all in one day; Group D-C, 20 second-10 second work-rest cycle, 12 trials given per day on three successive days.

The performance curves of the four groups for correct responses are shown in Figure 3. It will be noted that three of the four groups began the second task at essentially the same point. The fourth curve (Group C-C) began at a lower point, but the t-ratio between this point and the initial point of the other three curves was less than one. Groups D-A and C-A begin to diverge at abscissa point seven, which marked the beginning of a plateau for Group C-A, while the performance curve for Group D-A continued to rise to abscissa point 11 before reaching a plateau.

The decreases in performance over 24-hour rest intervals for Groups D-C and C-C are clearly shown in Figure 3. The slopes of the curves immediately after the 24-hour interval are steeper for Group D-C than for Group C-C. The loss over the rest intervals does not appear to be a function of the kind of practice, as the difference between the mean performance decrements for the two groups does not show a t-ratio greater than one.

The positive transfer effects can be seen by comparing the initial performance of the control groups (original task, Fig. 1) with the initial performance of the four groups on the final task (Fig. 3). There is no evidence of differential transfer effects from the original to the final task.

The means, SE's and t-ratios for the correct-response data for the four groups over the successive blocks of trials and the total trials are shown in Table 10. Further significant differences in the data may have been obscured by the heterogeneity of variance and unequal N's. A more sensitive test was not possible with these

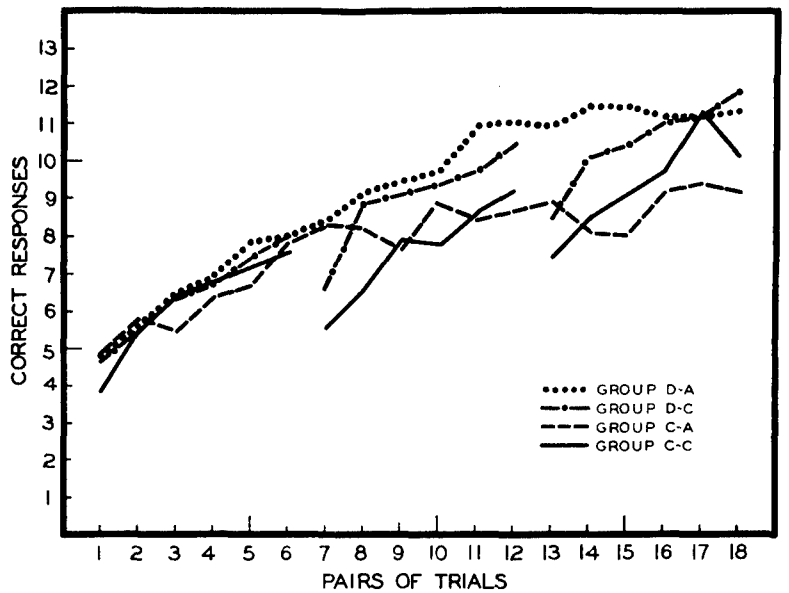

Fig. 3. Mean performance curves of correct responses on the final task for comparable groups from Experiment I (Groups D-A and D-C) and Experiment II (Groups C-A and C-C).

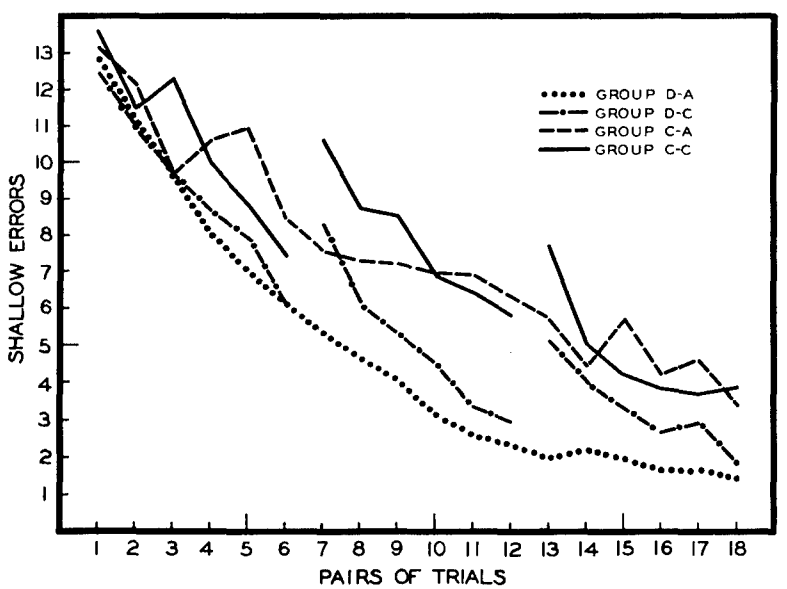

Fig. 4. Mean performance curves of shallow errors on final learning for comparable groups from Experiment I (Groups D-A and D-C) and Experiment II (Groups C-A and C-C).

Table 10 - Mean Number of Correct Responses of the Continuous-Practice Groups (C-A, C-C) from Experiment II and the Distributed-Practice Groups (D-A, D-C) from Experiment I for Various Blocks of Trials for the Final Task, Together with the t-Ratios for the Groups Compared

		Trials			
		1-12	13-24	25-36	1-36
Group C-A	Mean	73.53	100.80	105.33	279.06
	σ_m	4.61	9.41	7.13	20.65
Group C-C	Mean	74.60	91.13	113.13	278.86
	σ_m	6.44	7.86	8.41	20.79
Group D-A	Mean	79.09	119.24	136.50	331.35
	σ_m	3.69	4.55	4.18	11.18
Group D-C	Mean	77.30	106.93	125.84	310.08
	σ_m	3.56	4.33	4.79	11.51

t-Ratios[a]

	Trials			
Groups Compared	1-12	13-24	25-36	1-36
C-C vs C-A	.13	.71	.68	.00
C-C vs D-A	.60	2.93**	2.49*	2.23*
C-C vs D-C	.46	1.66	1.31	1.32
C-A vs D-A	.95	1.77	2.57*	2.23
C-A vs D-C	.31	.59	2.98**	1.32
D-A vs D-C	.11	1.96	1.68	1.31

*Significant at P = .05
**Significant at P = .01
[a]Because of unequal N's and occasional heterogeneous variance the t-ratios were computed by an approximation method (3, p. 167-170).

Table 11 - Mean Number of Shallow Errors of the Continuous-Practice Groups (C-A, C-C) from Experiment II and the Distributed-Practice Groups (D-A,D-C) from Experiment I for Various Blocks of Trials for the Final Task, Together with the t-Ratios for the Groups Compared

		Trials			
		1-12	13-24	25-36	1-36
Group C-A	Mean	129.93	84.40	55.87	270.20
	σ_m	11.96	12.94	7.93	29.53
Group C-C	Mean	127.60	94.27	56.60	278.47
	σ_m	11.16	15.07	13.04	35.55
Group D-A	Mean	109.64	44.42	21.80	175.91
	σ_m	7.57	5.56	3.55	14.99
Group D-C	Mean	111.60	61.00	38.98	211.60
	σ_m	6.57	6.00	5.61	15.38

t-Ratios[a]

	Trials			
Groups Compared	1-12	13-24	25-36	1-36
C-C vs C-A	2.17	.80	.35	1.13
C-C vs D-A	1.34	3.11**	2.58*	2.66*
C-C vs D-C	1.24	2.05	1.24	1.73
C-A vs D-A	1.43	2.84*	3.92**	2.86*
C-A vs D-C	1.35	1.65	1.75	1.76
D-A vs D-C	.19	2.02	2.62	1.66

*Significant at P = .05
**Significant at P = .01
[a]Because of unequal N's and occasional heterogeneous variance, the t-ratios were computed by an approximation method (3, p. 167-170).

restrictions. The heterogeneity of variances, however, did not appear to be systematic, as the greater variances were not always restricted to any one practice condition.

The performance curves for the shallow errors for the four groups are shown in Figure 4 and a summary of the analysis of the data is presented in Table 11. These data show much the same phenomena as the correct-response data and need not be detailed.

VI. DISCUSSION

The results of the present study provide no evidence of differential transfer effects as a function of distribution of practice. The superiority of spaced practice over continuous practice, in terms of level of performance, was, however, again demonstrated. When the performance curves of the two practice conditions were compared, the spaced groups were found to be at a significantly higher level of performance, in both the original and final tasks. However, in changing from the original to the final task, equal positive transfer was found for both practice conditions; the initial performance levels on the second task were essentially the same. The positive transfer effects of the spaced-practice condition were not surprising, as this condition (especially Group D-A) was comparable to one of several degrees of learning used in a previous study with the same tasks (2), where transfer effects of this magnitude were found. The continuous-practice condition, however, exhibited transfer effects that are not in accord with the implication behind the generally accepted superiority of spaced practice; namely, a higher level of acquisition. In the study mentioned above (2), positive transfer was found to increase as degree of original learning increased, and the rank order of the differential performance levels was maintained throughout the final task. In contrast, the results of the present study indicate that the level of learning was equivalent for the various groups of the two practice conditions, as the final task was begun. This equality of performance was continued for the first 12 trials of the final task.

To restate briefly what has been said: in the previous study differential positive transfer resulted from different levels of performance on the first task which were produced by varying the number of trials given on the first task. In the present study differential performance on the first task was produced by varying the distribution of practice, but no differential positive transfer was found. It is possible that in the previous study there was both differential <u>performance</u> and differential <u>learning</u> at the end of

practice on the first task, while in the present study there may have been only a temporary depression in performance in the continuous-practice group at the end of the first task. If so, that is, if the continuous-practice groups had actually learned as much as the spaced-practice group, no differential positive transfer would be expected. The performance curves of the two practice conditions did exhibit some characteristics that are commensurate with temporary work-decrement (1,4). During the first half of original learning, for the correct-response data (Fig. 1), the curves of the practice conditions were essentially the same. At abscissa point 10, the curves began to diverge, presumably due to the accumulation of decremental factors in the continuous-practice group which were not allowed time to dissipate. In the shallow-error data (Fig. 2), there was a suggestive, though not significant, increase in errors for the continuous-practice group. The negative factors that accrued during original learning for the continuous-practice group were presumably dissipated during the 24-hour interval between the original and final tasks, since the continuous-practice group began the final task at essentially the same point as the spaced-practice groups. This assumes that the factors that depressed the performance of the continuous-practice group during original learning were temporary. It is suggested, then, that continuous practice produced only a temporary depression in performance near the end of first-task practice; there was no differential positive transfer as a function of differential distribution of practice because learning of the first task was the same for all groups.

Another point that should be mentioned is the loss in performance that occurred over the 24-hour rests. This loss was suggested during original learning for the spaced-practice condition, although the decrements did not approach significance. In the final task, for both practice conditions, the losses could easily be seen for both correct responses (Fig. 3) and shallow errors (Fig. 4). The loss, or forgetting, did not appear to be a function of intra-day-distribution, or of inter-day-distribution of trials. There was no difference between the forgetting of Groups D-C and C-C over the 24-hour rest. However, the slope of recovery for Group D-C for correct responses was much steeper than the corresponding recovery for Group C-C, suggestive of a warm-up pheomenon. The slower recovery of Group C-C for correct responses and of both groups for errors may be an indication of interference from the original task, although there was no specific indication of overt interference in the data. Reminiscence, which is usually associated with continuous practice, was not found over the 24-hour interval.

VII. CONCLUSIONS

1. When practice on any one day on a self-paced discriminative motor task was spaced by short rests, performance on the first or training task was the same when all practice was given on one day as when practice was distributed over several days.

2. Transfer from the training to the final task was positive and was the same for all conditions of distribution over days of practice on the training task.

3. When practice within a day was made continuous, performance on the first task was poorer than when practice on any one day was spaced by short rests. The difference in performance was not great and did not produce differential transfer to the final task.

4. Transfer to the final task was the same whether a period of continuous practice or a period of spaced practice on the first task was given all on one day or distributed over several days.

5. Transfer to the final task was the same whether practice on the final task was by continuous or spaced practice and whether either condition was given all on one day or distributed over several days.

6. It was suggested all conditions of practice on the first task resulted in essentially equal learning of the task and that this was the reason why transfer to the final task was the same for all conditions.

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